8 Chemical Tests

Many types of chemical tests can be performed to assess varying aspects of stream water quality. However, volunteer monitoring programs are faced with both financial and technical limitations. Given these constraints, Hoosier Riverwatch trains volunteers to conduct eight of the chemical tests considered by the National Sanitation Foundation and *The Field Manual for Global Low-Cost Water Quality Monitoring* (Mitchell and Stapp, 1997) to be most useful in determining stream water quality:

Dissolved Oxygen
pH
Biochemical Oxygen Demand (5-Day)
Phosphates (Ortho and Total)
E. coli
Water Temperature Change
Nitrates
Turbidity

Riverwatch Chemical Testing Instructions

Hoosier Riverwatch does not require volunteers to use a standard set of equipment or methods for chemical testing. However, the majority of volunteer groups actively participating in the program have received equipment through Riverwatch grants. The chemical testing instructions presented in this chapter are for the most common methods used by volunteer stream monitoring groups in Indiana. They are also the methods presented during Riverwatch training sessions.

The methods are separated into two sections: Standard Chemical Testing Instructions and Advanced Chemical Testing Instructions. Standard Chemical Testing includes the use of the GREEN Standard Water Monitoring Kit. Advanced Chemical Testing includes the use of the HACH Stream Survey kit, Coliscan Easygel (for *E.*coli), and a turbidity tube. Detailed background information on each of the parameters is provided in the Advanced Chemical Testing section.

Hints For Performing Chemical Tests

- ✓ Read all of the instructions for each test before you perform the procedures.
- ✓ Do not store the Hach or GREEN chemical testing kits in your car or in any extreme temperatures.
- ✓ **Practice**! The more familiar you are with the tests, the easier they will be to perform, and the more accurate your results will be.
- ✓ Perform each procedure three times to assure precision and accuracy in your results.
- ✓ Wear protective gloves and safety goggles. Do not wear sunglasses when reading the test results.
- ✓ Rinse collection tubes or bottles with *sample* water before collecting the sample.
- ✓ Rinse testing tubes and bottles with *distilled* water after completing each test.
- ✓ Clean glassware with non-abrasive detergents or a solvent such as isopropyl alcohol. Use a soft cloth for wiping or drying. Do not use paper towels or tissue on plastic tubes as they may scratch.
- ✓ Wash your hands when you are finished.
- ✓ Obtain your water sample from the stream's main stream flow (usually in the middle). Take the sample 3-5 inches under the surface. See Figure 11 and more tips on the next page!

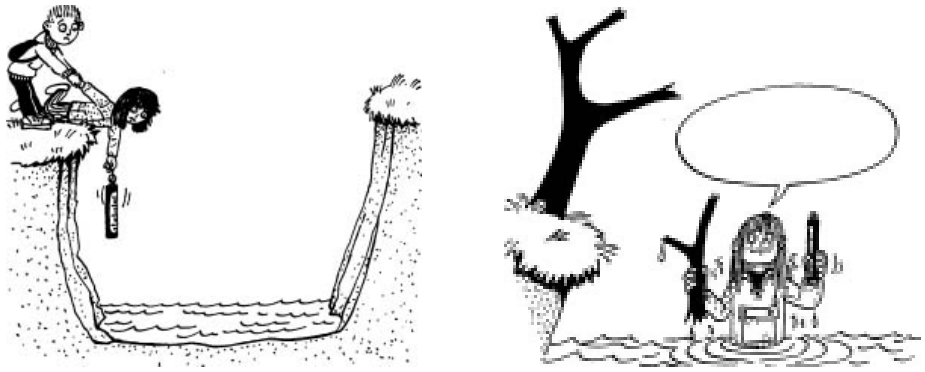
Tips on Collecting Water Samples

How you physically obtain the water sample depends on the size, depth, and banks of your stream. Most Hoosier Riverwatch volunteers sample wadeable streams. If you are wading, make sure that you collect water from a point upstream of where you are standing, being careful not to stir up any sediment. The sample must be collected in a clean container to avoid contamination. Collecting water directly from the stream with the container used for the chemical test is preferred.

Deep water or steep banks are dangerous (see Figure 11 below). Depending upon conditions at your site, you may need to use alternative sampling techniques. If you have a bridge at the site, you may be able to lower a sampling container or bucket down to the stream. At some sites, you may be able to sample with a rod (cup on a stick) from the edge of the stream. Regardless of the method of collection, sample water should be collected from the **main stream flow**.

Rinse your container three times with river water before collecting your final sample. Lower your container down 3 to 5 inches below the surface of the water so that your sample is representative of the whole stream.

Figure 11



Pictures from GLOBE 1997.

How to Discard Chemical Waste

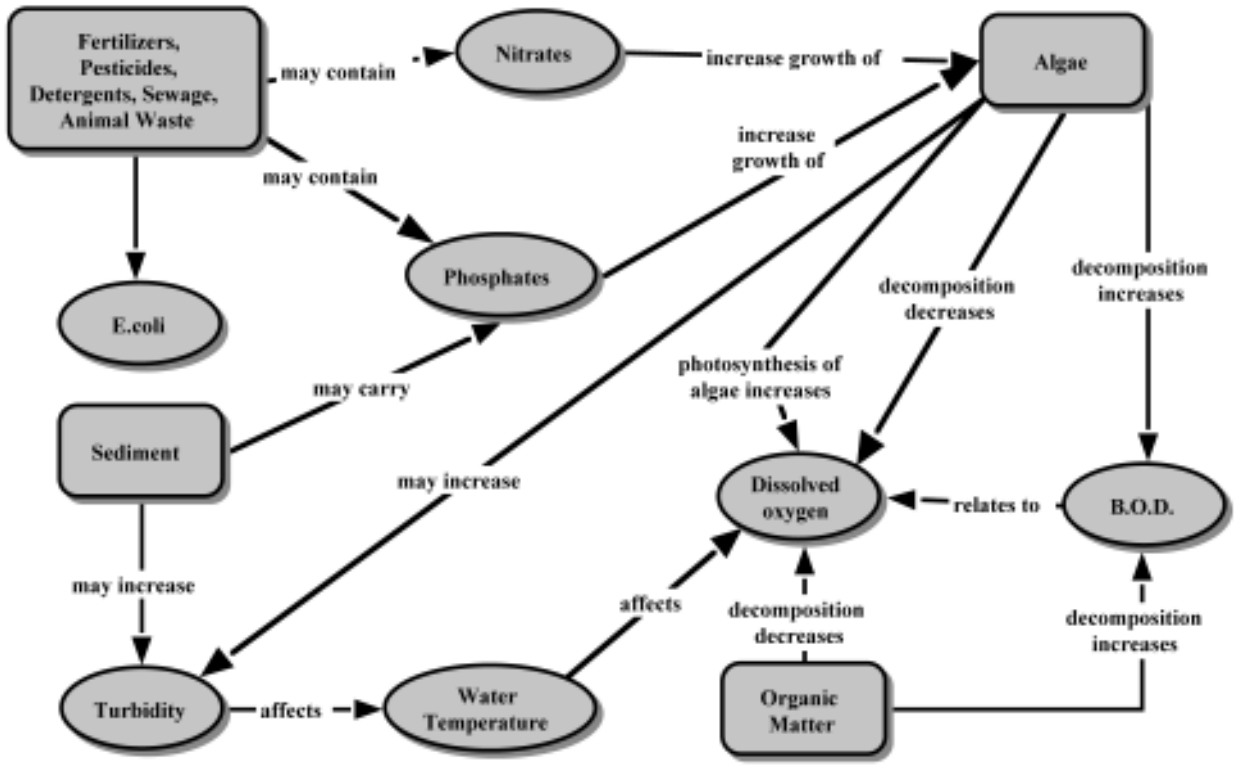
To discard chemical waste, label two separate containers with secure lids (such as a recycled margarine or milk containers). Label one "Hazardous Nitrate Waste" (HACH Nitrate Test Only) and one "Non-Hazardous Chemical Waste." Place all liquids and solids in the plastic containers along with several cups of clay cat litter. Allow the liquid to evaporate. The chemical waste is now in solid form.

You can dispose of the Hach Nitrate waste (which contains the heavy metal cadmium) by calling your local Solid Waste Management District. Your county may have Tox-Away Days which are sponsored by the Indiana Department of Environmental Management or Household Hazardous Waste Collection Days. All hazardous waste; including old paint, pesticides, cleaning agents, and Hach Nitrate waste can be taken in or picked up on these days. These collection events are designed for community members and are free.

The waste from all the other tests (including the GREEN nitrate test) is non-hazardous. Once in solid form, you can throw it away with your regular trash. If it's all in a liquid form, you may also wash it down the sink with plenty of water.

Water Monitoring Parameters are Interrelated

Aquatic chemistry is complex and is influenced by many interrelated factors. The simplified concept map below may help in understanding these relationships in an aquatic environment. The rectangles represent watershed inputs into a river or stream, while the circles represent chemical parameters we measure to determine water quality.



ppm vs mg/L

What does part per million mean? I'll explain with an example: 12 ppm of dissolved oxygen means that there are 12 molecules of oxygen in one million molecules of water. The following examples are listed on the "Water on the Web" (http://wow.nrri.umn.edu/wow/under/units.html) to provide further understanding of these units of concentration. One part-per-million is equal to:

- one car in bumper-to-bumper traffic from Cleveland to San Francisco
- one inch in 16 miles
- one minute in two years
- one ounce in 32 tons
- one cent in $10,000

So, how can it be that milligram per liter (mg/L) is the same as parts per million (ppm)? Well, a milligram per liter of water is equivalent to 1 ppm (part per million) because a liter of water weighs 1000 grams and a milligram is 1 one thousandth of a gram.

This is true for freshwater since the density of freshwater is 1 g/mL (1 g/mL = 10^{-3} g/10^{3} mL = 10^{-6}, or 1 ppm), but it does not hold for salt water because density increases with salinity.

The units **mg/L** and **ppm** are equal in fresh water.
They are used interchangeably throughout this chapter!

CHECKLISTS FOR GREEN CHEMICAL TESTS
(and Estimated Times to Complete the Tests)

These are Needed for All or Most of the GREEN Chemical Tests

- ❒ Material Safety Datasheets
- ❒ Hoosier Riverwatch Manual or GREEN Manual
- ❒ Standard Chemical Monitoring Datasheet
- ❒ Waste container (for Dissolved Oxygen, pH, BOD5, Orthophosphate, Nitrate tests)
- ❒ Watch or stopwatch (for Dissolved Oxygen, BOD5, Water Temp. Change, Orthophosphate, Nitrate tests)

Dissolved Oxygen Equipment **(GREEN Code 5889)** - **10 to 15 minutes**

- ❒ Small glass test tubes (0125)
- ❒ 2 DO TesTabs (3976)
- ❒ DO color chart/instruction card (6663)

pH Equipment **(GREEN Code 5890)** - **5 minutes**

- ❒ Plastic test tubes (0102)
- ❒ pH wide-range TesTabs (6459)
- ❒ pH color chart/instruction card (5890-CC)

BOD5 Equipment **(GREEN Code 5889)** - **(5 days to wait) then 10 to 15 minutes**

- ❒ Small glass test tubes (0125)
- ❒ Aluminum Foil (or dark bottle - BOD bottle, hydrogen peroxide bottle, etc.)
- ❒ 2 DO TesTabs (3976)
- ❒ DO color chart/instruction card (6663)

Water Temperature Change Equipment - **< 5 minutes**

- ❒ High-range and Low-range thermometers
- ❒ Temperature instruction card

Orthophosphate Equipment **(GREEN Code 5892) - 5 to 10 minutes**

- ❒ Plastic test tubes (0102)
- ❒ Phosphorus TesTabs (5422)
- ❒ Phosphate color chart/instruction card (5892-CC)

Nitrate Equipment **(GREEN Code 5891) - 10 minutes**

- ❒ Plastic test tubes (0102)
- ❒ Nitrate #1 TesTabs (2799)
- ❒ Nitrate #2 CTA TesTabs (NN-3703)
- ❒ Nitrate color chart/instruction card (5891-CC)

Turbidity Equipment **(GREEN Code 5887)** - **5 minutes**

- ❒ GREEN turbidity tube (0836)
- ❒ Turbidity chart/instruction card (5887-CC)

Coliform Bacteria Equipment **(GREEN Code 5880)** - **< 5 minutes (then 48 hrs)**

- ❒ Fecal coliform test tubes with tablet (3599)
- ❒ Coliform color chart/instruction card (5880-CC)
- ❒ Bleach

Note: Riverwatch does not use this method. See page 48 for instructions on using Coliscan Easygel.

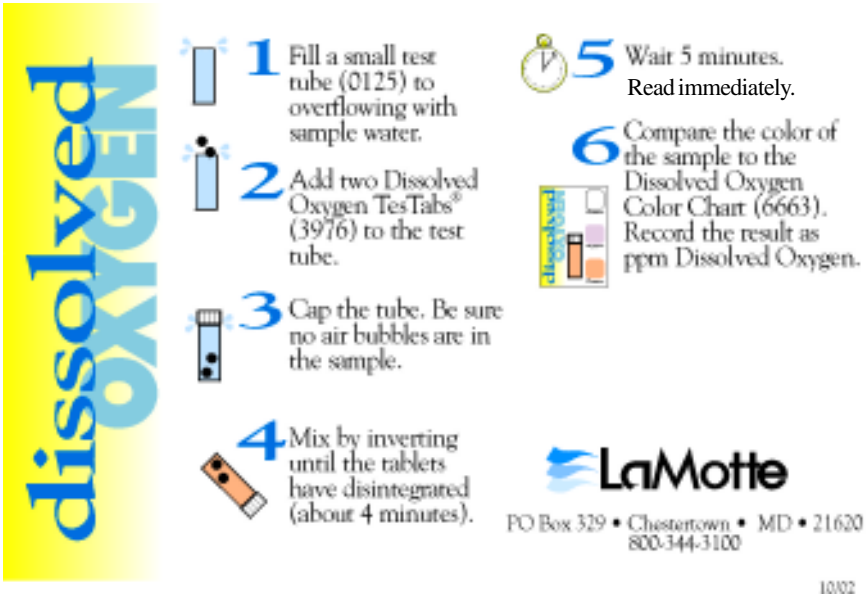
Standard Chemical (GREEN) Testing Instructions*

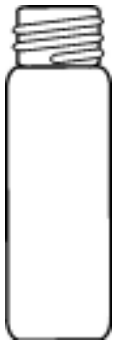
*Information and Instructions for the GREEN Standard Water Monitoring Kit provided with permission from Earth Force-GREEN and the LaMotte Company.

Dissolved Oxygen

Aquatic animals need oxygen to live. Oxygen dissolves readily into water from the atmosphere until water is saturated. Oxygen is also produced by aquatic plants, algae, and phytoplankton as a by-product of photosynthesis. Dissolved Oxygen levels below 3ppm are stressful to most aquatic organisms. Dissolved Oxygen levels below 2 or 1ppm will not support fish. Levels of 5 to 6 ppm are usually required for growth and activity.

Dissolved Oxygen Percent Saturation is an important measurement of water quality. Cold water can hold more dissolved oxygen than warm water. For example, water at 28°C will be 100% saturated with 8ppm dissolved oxygen. However, water at 8°C can hold up to 12ppm of oxygen before it is 100% saturated. High levels of bacteria from sewage pollution or large amounts of rotting plants can cause the percent saturation to decrease. This can cause large fluctuations in dissolved oxygen levels throughout the day, which can affect the ability of plants and animals to thrive.





Actual size of DO bottle

Step 7. Record the temperature of the water sample. See page 38 for information on using the GREEN kit thermometer.

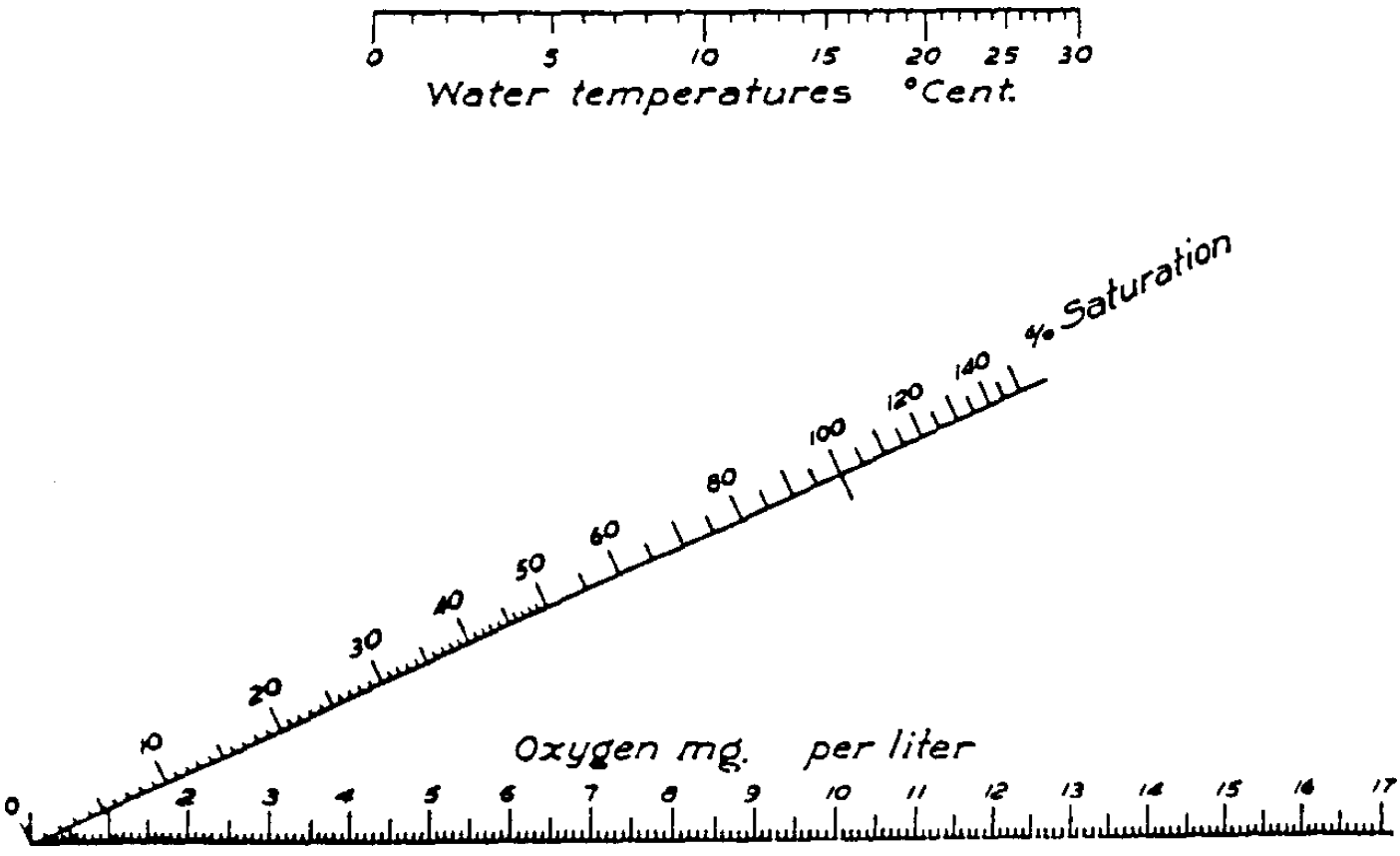
Step 8 is on the next page!

Step 8.

Determine the % Saturation of Dissolved Oxygen using the chart at the right or the graph shown below.

Dissolved Oxygen % Saturation

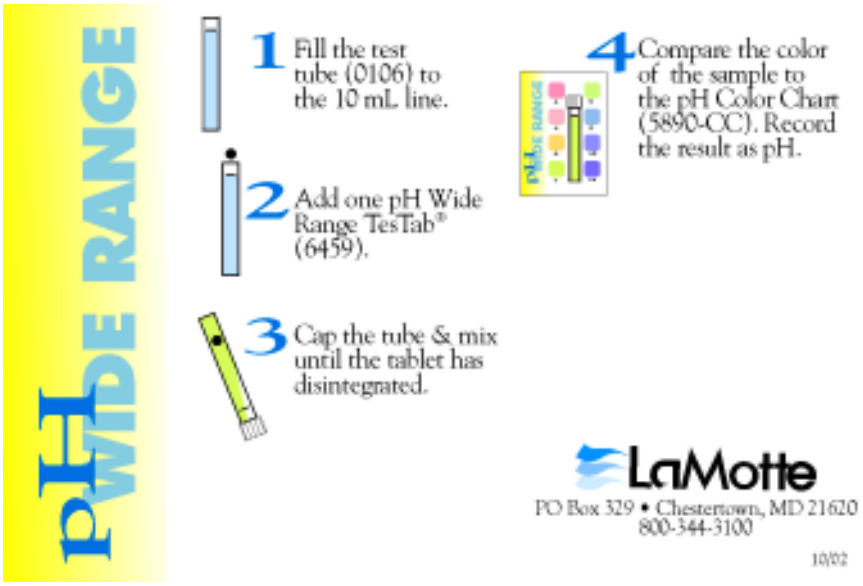
Temp °C	0ppm	4ppm	8ppm
2	0	29	58
4	0	31	61
6	0	32	64
8	0	34	68
10	0	35	71
12	0	37	74
14	0	39	78
16	0	41	81
18	0	42	84
20	0	44	88
22	0	46	92
24	0	48	95
26	0	49	99
28	0	51	102
30	0	53	106



pH

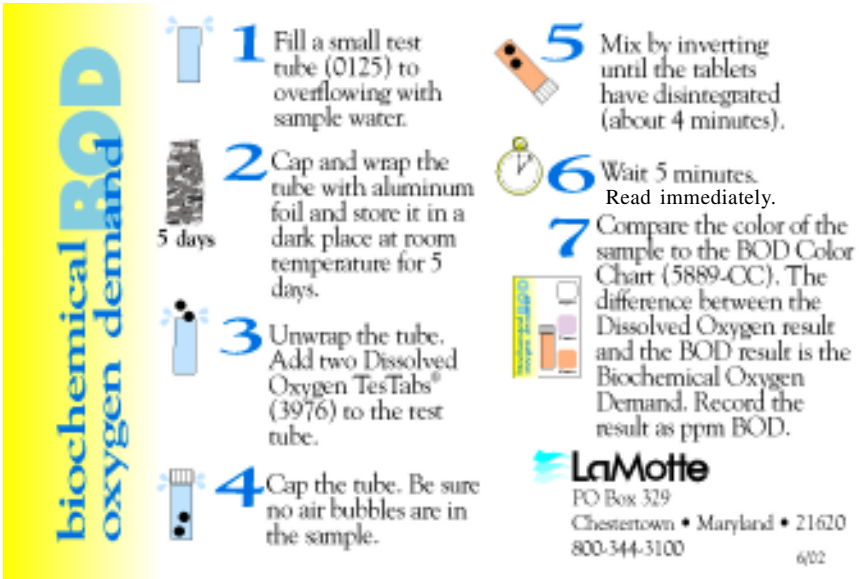
The pH test is one of the most common analyses in water testing. pH is a measure of the activity of hydrogen ions in a water sample. The pH scale ranges from 0 to 14. Water samples with a pH below 7.0 are acidic, those above 7.0 are basic, with 7.0 considered neutral.

A pH range of 6.5 to 8.2 is optimal for most organisms. Rapidly growing algae and vegetation remove carbon dioxide (CO_2) from the water during photosynthesis, which can result in a significant increase in pH. Most natural waters have pH values from 5.0 to 8.5. Acidic, freshly fallen rainwater may have a pH of 5.5 to 6.0. Alkaline soils and minerals (limestone) can raise pH to 8.0-8.5. Seawater usually has a pH close to 8.0.



Biochemical Oxygen Demand (5-Day)

Biochemical Oxygen Demand (BOD) is a measure of the quantity of dissolved oxygen used by bacteria as they break down organic wastes. High BOD levels indicate that large amounts of organic matter are present in the stream. In slow-moving and polluted waters, much of the available dissolved oxygen is consumed by bacteria, robbing other aquatic organisms of the dissolved oxygen needed to live.



BOD_5 =

Dissolved Oxygen ppm

(original sample)

-minus-

Dissolved Oxygen ppm

(after 5 days)

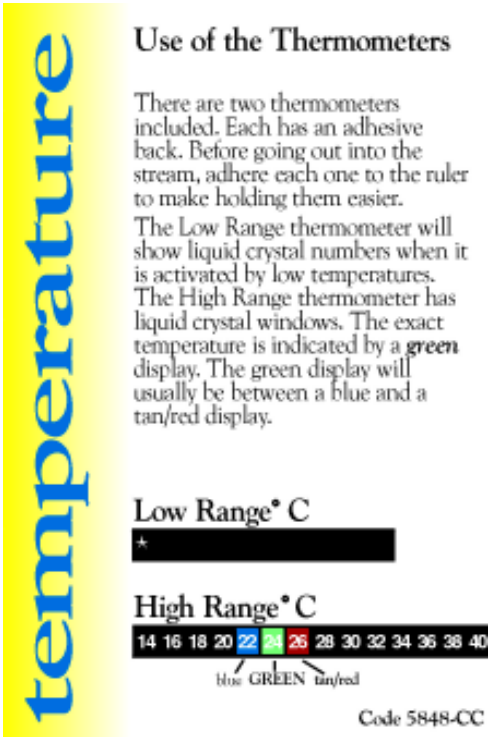
Fecal Coliform or *E. coli*

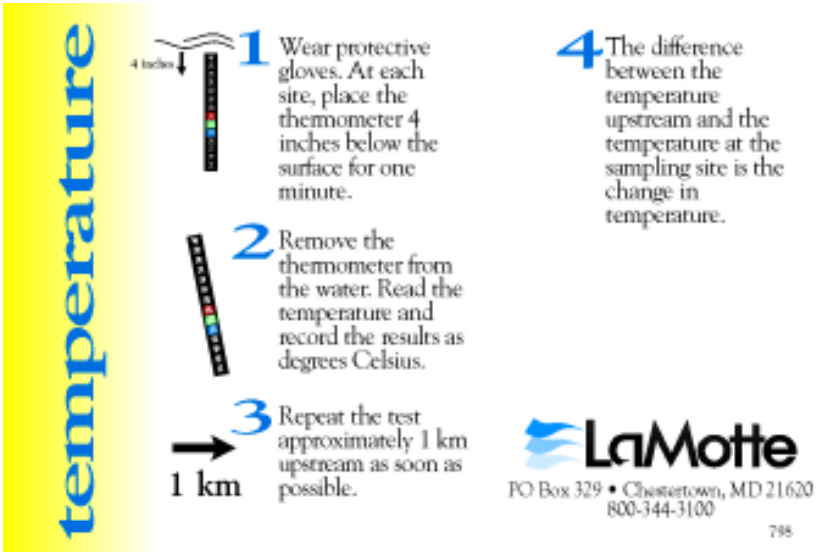
Hoosier Riverwatch recommends Micrology Lab's Easygel method for *E.*coli. See page 48 for instructions.

Water Temperature Change (1 mile)

Temperature is very important to water quality. Temperature affects the amount of dissolved oxygen in the water, the rate of photosynthesis by aquatic plants, and the sensitivity of organisms to toxic wastes, parasites and diseases. Thermal pollution, the discharge of heated water from industrial operations, for example, can cause temperature changes that threaten the balance of aquatic systems. The same thermometer or temperature measuring device should be used at both sites.

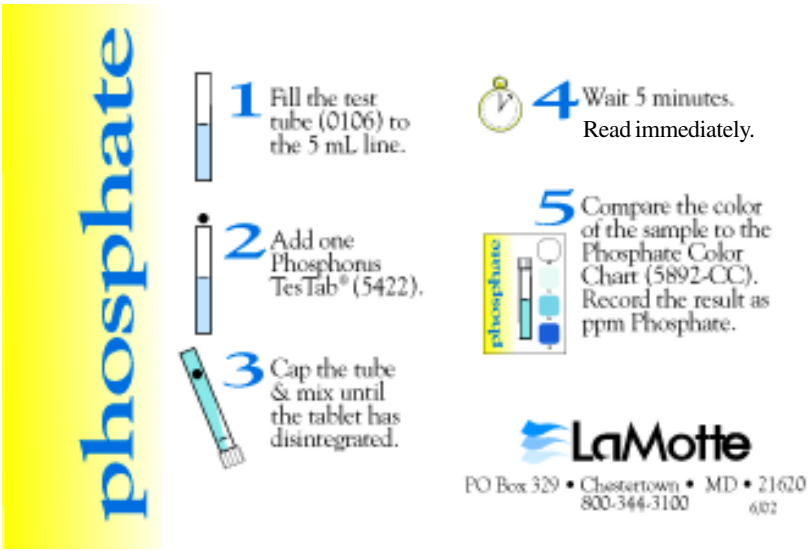
Use the following equation: Temperature at Site (Downstream) - Temperature 1 mile Upstream **= Water Temperature Change**





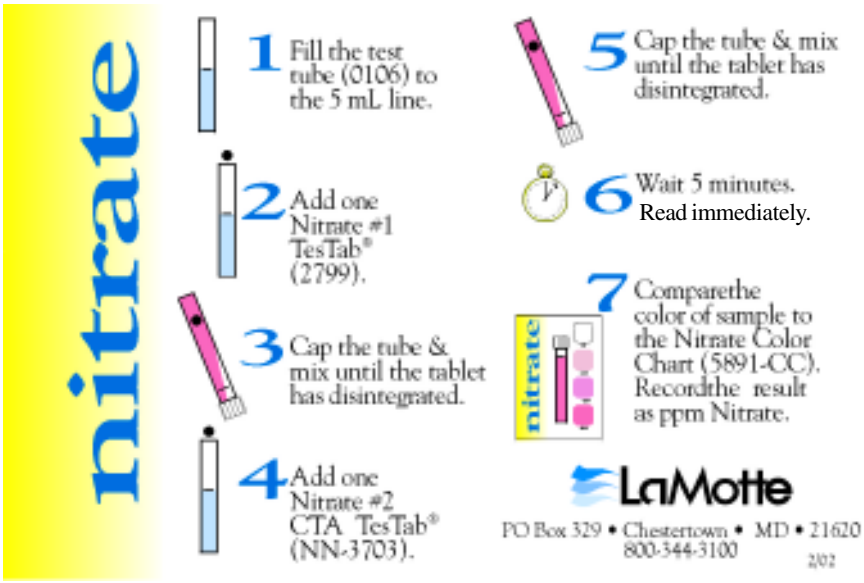
Orthophosphate

Phosphorus is a nutrient that acts as a fertilizer for aquatic plants. When nutrient levels are high, excessive plant and algae growth creates water quality problems. Phosphorus occurs in natural waters in the form of phosphates (PO_4), although over half of the phosphates in lakes, streams, and rivers come from human uses. Phosphate levels higher than 0.03ppm contribute to increased plant growth.



Nitrate (NO_3)

Nitrogen is a nutrient that acts as a fertilizer for aquatic plants. When nutrient levels are high, excessive plant and algal growth creates water quality problems. Nitrogen enters the water from human and animal waste, decomposing organic matter, and runoff of fertilizer from lawns and crops. Nitrogen occurs in water as Nitrate (NO_3), Nitrite (NO_2), and Ammonia (NH_3). Unpolluted waters usually have a nitrate level below 4ppm. Nitrate levels above 40ppm are considered unsafe for drinking water.

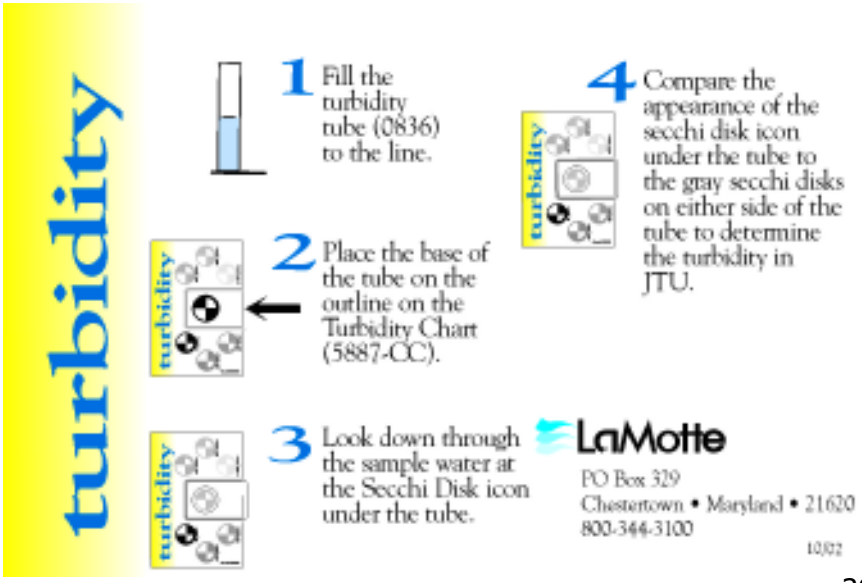


Turbidity

Turbidity is the measurement of the relative clarity of water. Turbid water is cloudy and is caused by suspended and colloidal matter such as clay, silt, organic, and inorganic matter, and microscopic organisms (algae). Turbidity should not be confused with color, since darkly colored water can still be clear and not turbid. Turbid water may be the result of soil erosion, urban runoff, algal blooms, and bottom sediment disturbances that can be caused by boat traffic and abundant bottom feeding fish.

Turbidity is measured in Nephelometer Turbidity Units (NTUs) or Jackson Turbidity Units (JTUs), which are roughly equal to each other.

Collect a small bucketful of water. Be careful not to disturb the sediments on the stream bottom. Shake the sample vigorously to mix it well before examination.



Standard Chemical Data Sheet Instructions

The Standard Chemical Monitoring Data Sheet is to be used when most or all of the chemical tests are completed using the Standard Chemical Testing Instructions and the GREEN Standard Water Monitoring Kit. (The primary exceptions are the use of Coliscan Easygel for E. coli testing and a turbidity tube for turbidity monitoring **- record these results on the Advanced Chemical Data Sheet.)** Please note that use of the data sheets in the GREEN kit manual will produce different results.

Ranges are used for many of the parameters in the Standard data sheet because the results obtained using the GREEN kit are not very precise. This data sheet uses a simple scale that counts each test equally and averages the results; therefore, it does not matter how many tests are completed.

To complete the data analysis section, check the boxes in the appropriate categories for the results you receive. Add the number of boxes checked in each category. Multiply the number of checks by the weighting factors. Add the final column totals, then divide this value by the number of tests completed to receive a final averaged value.

In addition, write each actual value in the blank space next to each test to keep for your records.

Example	Excellent	Good	Fair	Poor
Dissolved Oxygen (% saturation)	☐ 110 - 91	☑ 90 - 71	☐ 70 - 51	☐ <50
BOD5 (ppm = mg/L) DO original sample 8ppm minus DO 5-Day sample 8ppm	☑ 0	☐ 2 - 4	☐ 6 - 8	☐ >8
Nitrate (ppm) *(Note: values are estimated)*	☐ 0 clear	☑ >0 - <5	☐ 5	☐ >5
pH	☐ 7	☐ 6 or 8	☐ 5 or 9	☐ <4 or >10
OrthoPhosphate (ppm)	☑ 0 clear	☐ > 0 - 2	☐ > 2 - 4	☐ >4
Temperature change (°C) Downstream site 22°C minus Upstream 1-mile 21°C	☑ 0 - 2	☐ 3 - 5	☐ 6 - 10	☐ >10
Turbidity (NTU = JTU)	☐ 0	☐ >0 - 40	☑ >40 - 100	☐ >100
***E. coli* (colonies/100mL)** 1,200 colonies	☐ 0	☐ 1 - 300	☐ 301 - 500	☑ >500
Add # of Checks in Each Column	3	2	1	1
	# Excellent x 4	# Good x 3	# Fair x 2	# Poor x 1
	12	6	2	1

Excellent	**4**
Good	**3**
Fair	**2**
Poor	**1**

Add Column Totals: 21 ÷ # of Tests Performed: 7 = **Overall Water Quality**: 3, Good!

STANDARD CHEMICAL MONITORING (GREEN) DATA SHEET

Date ____/____/____ (MM DD YY) Begin Time _____:_____ (am/pm) # Adults _____

End Time _____:_____ (am/pm) # Students _____

Certified Monitors' Names_____ Volunteer ID_____

Organization Name _____

Watershed Name _____ Watershed # __ __ __ __ __ __ __ __

Stream/River Name _____ Site ID _____

(Please do not abbreviate.) (Above ID numbers are required.)

Current Weather ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (Steady) ☐ Storm (Heavy)

Weather in Past 48 hrs. ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (Steady) ☐ Storm (Heavy)

	Excellent	Good	Fair	Poor
Dissolved Oxygen (% saturation)	☐ 110 - 91	☐ 90 - 71	☐ 70 - 51	☐ <50
BOD5 (ppm = mg/L) **DO original sample** _____ minus **DO 5-Day sample** _____	☐ 0	☐ 2 - 4	☐ 6 - 8	☐ >8
Nitrate (ppm) ***(Note: values are estimated)***	☐ 0 clear	☐ >0 - <5	☐ 5	☐ >5
pH	☐ 7	☐ 6 or 8	☐ 5 or 9	☐ <4 or >10
OrthoPhosphate (ppm)	☐ 0 clear	☐ > 0 - 2	☐ > 2 - 4	☐ >4
Temperature change (°C) **Downstream site** _____ minus **Upstream 1-mile** _____	☐ 0 - 2	☐ 3 - 5	☐ 6 - 10	☐ >10
Turbidity (NTU = JTU)	☐ 0	☐ >0 - 40	☐ >40 - 100	☐ >100
***E.* coli (colonies/100mL)**	☐ 0	☐ 1 - 300	☐ 301 - 500	☐ >500
Add # of Checks in Each Column				
	# Excellent x 4	# Good x 3	# Fair x 2	# Poor x 1

Excellent	**4**
Good	**3**
Fair	**2**
Poor	**1**

Add Column Totals ÷ # of Tests Performed = **Overall Water Quality**